PATENT SPECIFICATION

(11) 1 523 380

1 523 380

(21) Application No. 43202/76 (22) Filed 18 Oct. 1976

(44) Complete Specification published 31 Aug. 1978

(51) INT CL² G01N 19/02//G01L 3/10

(52) Index at acceptance

G1S 5

G1N 1C 1D3 7J 7T1A

(19)

(72) Inventors NIKOLAI IVANOVICH KUSKOV
VLADIMIR SERGEEVICH BELIKOV
BER LEIZEROVICH SMUSHKOVICH
AVTANDIL VISSA RIONOVICH CHICHINADZE
and
EDUARD DAVIDOVICH BRAUN

(54) MACHINE FOR TESTING SPECIMENS OF MATERIALS FOR FRICTION AND WEAR

(71) We, SPETSIALNOE KONSTRUKTORSKOE BJURO PO RAZRABOTKE AVTOMATICHESKIKH SREDSTV IZMERENIA MASS I PRIBOROV ISPYTATELNOI TEKHNIKI (SKB IMIT), a Corporate Body of the U.S.S.R. of Ivanovo, Lezhnevskoe Shosse, 183, U.S.S.R., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to machines for testing specimens of materials for friction and wear.

A known machine for this purpose has a spindle driven by an electric motor. Mounted on the spindle is a holder for a test specimen made in the form of a disc. The spindle is housed in a casing mounted on a frame which also carries a device for applying load to the test specimens, including a solid shaft aligned with the spindle, a disc rigidly fixed on the end of the shaft and carrying three specimen holders facing the specimen holder on the spindle, and an air-operated cylinder acting upon the shaft so as to urge it toward the spindle. The holders on the shaft are spaced 120° apart from each other and are made in the form of spring collets. The specimens to be tested and held in the collets are made in the form of pins with cylindrical or polygonal cross section.

The end of the shaft facing the air cylinder is connected with the resilient element of a torque gauge.

The air cylinder acting upon the shaft, moves it along with the disc toward the spindle and presses the test specimens held on the spindle and the disc together. During the spindle rotation, relative movement of the specimens under load takes place, and a moment of friction arises in the frictional engagement pair composed of the disc and the pins. The moment of friction tends to turn the shaft in the direction of the spindle rotation whereby the resilient element is deformed. The torque gauge transducer (dynamometer) transforms the deformation of the resilient element into an electric signal fed to a measuring and recording unit of the gauge.

Since the shaft transmits to the specimens the axial load as well as the moment of friction, it carries the resilient element and the torque transducer along in the axial direction. The shaft is fixed against rotation under the action of the frictional moment by means of suitable guideways allowing its axial movement only.

The friction force arising between the shaft and the guideways depends on the moment of friction produced by the test specimens. This causes uncontrollable fluctuations of the load and the moment of friction on the specimens in the process of testing. As a result, the value of the coefficient of friction of the material under test becomes distorted.

Moreover, unavoidable clearances between the shaft and the guide ways result in vibration of the machine during tests.

As the disc is rigidly fixed on the shaft, it is not capable of self-alignment. Accordingly, no uniform pressing of the pin-type test specimens against those of the disc type can be provided, which also affects the measured results.

Here, a long period of time for wear-in of the test specimens is also necessary.

The above mentioned disadvantages of the described machine decrease reliability of the measured results.

Besides, this machine provides the tests for the frictional engagement pair of the pin-and-disc type only.

In accordance with the present invention there is provided a machine for testing

specimens of materials for friction and wear comprising a frame, a spindle for carrying a test specimen at an end face thereof mounted on the frame, drive means for rotating the spindle, a hollow shaft aligned with the spindle and coupled to a torque gauge, a rod coaxially disposed within the hollow shaft and axially movable relative thereto, means for urging the rod towards the spindle, a disc for carrying a test specimen facing a test specimen carried on the spindle, the disc being connected to the rod through a joint catering for self-alignment of the disc for pressing the test specimens together uniformly, and means connecting the disc to the hollow shaft for transmitting frictional torque from the disc to the hollow shaft, the connecting means being arranged to permit axial displacement of the disc together with the rod relative to the hollow shaft. Such a machine for testing specimens of materials for friction and wear allows the transmission of load to the test specimens and determination of the moment of friction and, accordingly, the coefficient of friction, without distortions.

Furthermore the machine can ensure shortened periods of time for wear-in of the test specimens.

The means for urging the rod axially preferably comprises a fluid operated cylinder.

The presently preferred embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of the machine for testing specimens of materials for friction and wear according to the present invention;

Figure 2 shows the device for applying load to the test specimens and transmitting the moment of friction from the specimens to the torque gauge, and also shows the air-operated cylinder in axial section;

Figure 3 is a view in the direction of arrow "A" of Figure 2;

Figures 4—7 show alternative embodiments of the design and arrangement of the elements connecting the disc to the hollow shaft;

Figure 8 is a view in the direction of arrow "B" of Figure 2 on an enlarged scale;

Figure 9 shows schematically a frictional engagement pair of the disc-and-pin type;

Figure 10 is a view in the direction of arrow "C" of Figure 9;

Figure 11 shows schematically a frictional engagement pair of the ring-and-ring type;

Figure 12 shows schematically a frictional engagement pair of the shaft-and-sleeve type; and

Figure 13 shows a chamber for mounting on the machine for testing specimens of shaft-and-sleeve type.

The machine for testing specimens of materials for friction and wear shown in Figures 1—12 has a driving spindle 1 (Figure 1) which is mounted in its casing 2 in bearings 3 and is driven by an adjustable-speed electric motor 4 through a belt transmission 5. The spindle 1 is interconnected through a worm gearing 6 with a shaft 7 which carries at one end a tachometer 8, and at the other end, a crank 9. Installed on the spindle is a holder 10 wherein a test specimen 11 is fixed. The casing 2 of the spindle is mounted on a frame 12.

The frame 12 also carries a device 13 (Figures 1 and 2) serving to transmit load to the test specimens 11 and 14 and the moment of friction from the specimens 14 to a torque gauge 15, and an air-operated cylinder 16.

The air cylinder 16 is mounted on a casing 17 which carries the device 13 and is adjustable along the frame 12 toward or away from the spindle 1 by rotating a screw 18 by means of a handwheel 19. The casing 17 is fixed on the frame 12 by a clamp 20.

The air cylinder 16 is provided with a membrane 21 hermetically connected to a cover 22. Compressed air is delivered to the air cylinder 16 through an air duct 23 and acts upon a piston 24 (the direction of the input air stream is designated by the arrow).

The device 13 has a hollow shaft 25 mounted in casing 17 by means of bearing 26. A flange 27 and a lever 28 (Figures 1, 2 and 3) are rigidly fixed to the shaft 25 on the side of the spindle 1 and the air cylinder 16, respectively. An adjustable stop 29 can be moved along the lever 28 and fixed in a desired position with a bolt 30. The stop 29 contacts a resilient element 31 of the torque gauge 15 fixed to the casing 17.

Deformation of the resilient element 31 is transformed into an electric signal by a transducer 32 (Figures 2 and 3), which may be, for instance, of an inductive type. The signal is fed to the measuring and recording unit of the gauge (not shown).

A rod 34 is disposed coaxially inside the hollow shaft 25 in guide ways 33 (Figures 1 and 2) and is adapted to be moved along its axis.

Mounted between the rod 34 and the piston 24 is a thrust bearing 35 wherethrough the air cylinder 16 interacts with the rod 34.

A spherical ball bearing 36, defining a rotary joint, is installed on the end of the rod 34 facing the spindle 1. A disc 37 is connected to the rod 34 through the bearing 36 whereby the disc 37 can be self-

aligned so as to uniformly press together the test specimens 11 and 14. The outer ring 36*a* (Figure 2) of the bearing 36 is fixed in the disc 37 (Figures 1 and 2), and this arrangement does not allow the disc to be displaced axially relative to the rod 34.

A ring 38, mounted on the disc 37, is rotatable about the disc axis, but fixed against the axial movement.

The ring 38 is connected to the disc 37 through pins 39, secured in the ring, and resilient bushings 40 (Figure 2) fitted into bores "a" of the disc, and also through bolts 41.

The bolts 41 can be removed. In this case, the ring 38 is connected to the disc 37 through the pins 39 and the bushings 40 only.

Connecting elements 42 through which the ring 38 is connected to the flange 27 fixed to the hollow shaft 25 are fastened to the flange 27 and the ring 38 (Figures 1 and 2).

Embodiments of the elements 42 are shown in Figures 4—7.

Figure 4 shows a connecting element 42*a* obtained by cutting a thin flat ring 42*b* round the lines "*b*". The leaves 42*c* so formed are fastened to the ring 38 through holes "*c*", whereas the rest 42*b* of the ring is fastened to the flange 27 through holes "*d*".

Figure 5 schematically shows the mounting of the element 42*a* between the ring 38 and the flange 27. Here, the ring 38 is shifted relative to the flange 27 at a distance "δ" because of the deformation of leaves 42*c*.

Figure 6 illustrates an embodiment of the connecting element 42*d* made from separate leaves 42*e* which are fastened to the ring 38 and the flange 27 through the respective holes "*e*" and "*f*". In this case, the elements 42*a* and 42*d* are made of beryllium bronze or another material with adequate strength and low internal friction.

Figure 7 shows an element 42*f* produced from separate flexible steel cables 42*g* each secured with its end "*g*" to the ring 38, and with the other end "*h*", to the flange 27.

In all the described examples, the connecting elements are mounted so as to prevent the turning of the ring 38 and the disc 37 in respect to the flange 27 in the direction where the moment of friction acts. Thus, the elements 42 always transmit the moment of friction from the disc 37 through the hollow shaft 25 of the torque gauge 15 and, at the same time, allow the movement of the disc 37 together with the rod 34 in the axial direction and the self-alignment of the disc 37 on the bearing (joint) 36.

The disc 37 (Figure 8) carries holders 43 for the test specimens 14 facing the holder 10 for the test specimen 11 which, in turn, is secured on the spindle 1. The holders 43 are provided with spring collets 44 mounted in holes "i" of the disc 37, which are disposed at different radii R, and also with stepped clamping rods 45 which, in turning nuts 46, move in radial directions to clamp or release the collets 44 with their cut-away portions "*j*".

Three specimens at a time should be placed on the disc 37 120° apart from each other and at identical radii R for applying the friction force.

Made in the disc 37 are ducts "K" communicating with each other and connected through tubes 47 used for the supply of a coolant liquid, e.g. water. A tube "K_1" serving to deliver coolant to the disc 37 is shown in Figure 2.

The test specimens 11 and 14 form a frictional engagement pair.

The described embodiment of the machine provides for testing the disc-and-pin type specimens, as shown in Figure 9 and 10, i.e. the frictional engagement pair is formed by a disc-type rotating specimen 11, secured on the spindle 1, and three pin-type specimens 14, clamped in the holders 43 on the disc 37. The pin-type specimens may have a round or some other contour in cross section.

Specimens of other types may also be tested on the machine.

To test a frictional engagement pair of the ring-and-ring type, shown in Figure 11, one specimen 48 of the pair is fixed in a holder (not shown) on the spindle 1, and the other specimen 49, in a holder (not shown) disposed at the centre of the disc 37.

A pair of the shaft-and-sleeve type consisting of a shaft 50 and a sleeve 51, shown in Figure 12, is tested on the machine of the invention which is equipped for this purpose with a special chamber 52 illustrated in Figure 13.

The chamber 52 is secured to the disc 37 with bolts (not shown) through holes "*l*". Mounted within the chamber in bearings 54 is a holder 55 whose flange 56 is coupled to the holder 10, and hence spindle 1 through holes "*m*" by means of bolts (not shown). The shaft-type specimen 50 is fixed on the holder 55 by means of a pin 57. The stationary sleeve-type specimen 51 is fixed in a holder 58 whose spherical portion 59 is fitted into a sleeve 60 to prevent the holder from turning about the specimens' axis. The specimens 50 and 51 are loaded by an air-operated cylinder 61 similar to the cylinder 16 of the machine.

The chamber 52 may also be installed directly on the frame 12. In this case, the crank 9 may be hingedly linked to the flange 56 through holes "*m*" with the aid of a connecting rod (not shown). With the chamber 52 so arranged the specimen 50

performs a rocking movement in the process of testing, which is useful for testing the wear characteristics of the specimens ; of course with this arrangement measurement of the torque generated by the friction between the specimens is not possible. For all the variants of tests on the machine, provision is made of thermocouples (not shown) placed in the test specimens for measuring temperature arising in the contact zone.

The described test variants offer a scientific approach to the simulation of the frictional engagement pairs' action in machine units.

When pressure is applied is applied to the specimens under test, the disc 37 is freely self-aligned on the spherical ball bearing (rotary joint) 36 so that the three specimens 14 are pressed uniformly to the specimen 11.

In the relative movement of the test specimens 14 and 11 due to the rotation of the spindle 1, a moment of friction arises which tends to turn the disc 37 in the direction of spindle rotation.

The moment is transmitted through the elements 42 to the hollow shaft 25, and the lever 28, fixed on the shaft, deflects with its stop 29 the resilient element 31 of the torque gauge 15.

The deflection of the resilient element 31 is proportional to the moment of friction, and its maximum value can be set by adjusting the stop 29 to the required position on the lever 28, which causes variation in the arm length for the force acting on the element 31.

Deflection of the resilient element 31 results in variation of the electric signal from the transducer (dynamometer) 32 of the torque gauge 15, which signal is detected by a measuring and recording unit, e.g. an electronic potentiometer or an oscillograph (not shown).

As the test specimens are subject to wear in the process of testing, the disc 37 with the holders 43 is displaced axially under the action of the air cylinder 16.

In the machine according to the present invention, the moment of friction is transmitted through the hollow shaft 25, whereas the test specimens 11 and 14 are loaded by means of the rod 34 coaxially extending through the shaft 25. Thus, the axial load and the moment of friction are transmitted separately in the machine, whereby the load and the moment do not affect each other and can be accurately determined.

Since the connecting elements 42 have no parts moving relative to each other, they transmit the moment of friction without shocks and impacts. Moreover, the moment of friction causes no additional friction force which can distort the load on the test specimens 11 and 14, produced by the air cylinder 16, and so affect the moment of friction.

Because of the self-alignment of the disc 37 on the bearing 36 uniform loading and thus uniform wear of the test specimens 14 is ensured. At the same time, the disc 37 is capable of transmitting the moment of friction with no loss of steadiness. In addition, the period of time required for wear-in of the test specimens 11 and 14 is shortened.

The resilience of the connecting elements 42 in the axial direction is sufficient not to appreciably affect the transmission of the load to the test specimens 14 regardless of the frictional moment value perceived by the element 42. Since no parts with clearance fits are used in the construction of the elements 42, no vibration arises in the device 13 to influence the results of the frictional moment measurement.

The described features of the machine provide for reliable results of testing and, in particular, for the determination of the coefficient of friction, whose accuracy depends on that of the transmission of load to the test specimens and that of the frictional moment measurement.

Where the variations in the moment of friction arising in a frictional engagement pair during the tests are required to be determined, the disc 37 is rigidly connected to the ring 38 by means of the bolts 41 as shown in Figure 2.

If averaged characteristics of the pair are to be measured the bolts 41 are removed, and the oscillations of the disc 37 are absorbed by the resilient bushings 40.

The specimens are tested until the specified value of wear is reached. This may be checked by the displacement of the rod 34.

In the process of testing, measurement is made of the total number of revolutions performed by the spindle 1. This is carried out by means of the tachometer 8 and a revolution counter (not shown).

The tests are completed as follows.

Compressed air is exhausted from the air cylinder 16 and the spindle speed is gradually reduced until the spindle is stopped.

Then, by rotating the handwheel 19 the specimens 14 are brought out of engagement with the specimen 11 and all the specimens are removed from the respective holders 10 and 43.

The testing of the ring-and-ring type specimens is similar to that described above.

In testing the shaft-and-sleeve type specimens, the moment of friction arising in

the frictional engagement pair is transmitted from the holder 58 through the spherical joint 59 to the sleeve 60 and flange 53 through which the chamber 52 is fixed to the disc 37. Here, the moment of friction is transmitted to the disc 37, and its further transmission and measurement are similar to those described above. The test specimens are here loaded by the air cylinder 61.

WHAT WE CLAIM IS:—

1. A machine for testing specimens of materials for friction and wear comprising a frame, a spindle for carrying a test specimen at an end face thereof mounted on the frame, drive means for rotating the spindle, a hollow shaft aligned with the spindle and coupled to a torque gauge, a rod coaxially disposed within the hollow shaft and axially movable relative thereto, means for urging the rod towards the spindle, a disc for carrying a test specimen facing a test specimen carried on the spindle, the disc being connected to the rod through a joint catering for self-alignment of the disc for pressing the test specimens together uniformly, and means connecting the disc to the hollow shaft for transmitting frictional torque from the disc to the hollow shaft, the connecting means being arranged to permit axial displacement of the disc together with the rod relative to the hollow shaft.

2. A machine according to claim 1 wherein the means for urging the rod axially comprises a fluid operated cylinder.

3. A machine for testing specimens of materials for friction and wear as herein before described with reference to Figures 1 to 12 or Figures 1 to 12 and 13 of the accompanying drawings.

A. A. THORNTON & CO.,
Chartered Patent Agents,
Northumberland House,
303/306, High Holborn,
London, WC1V 7LE.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

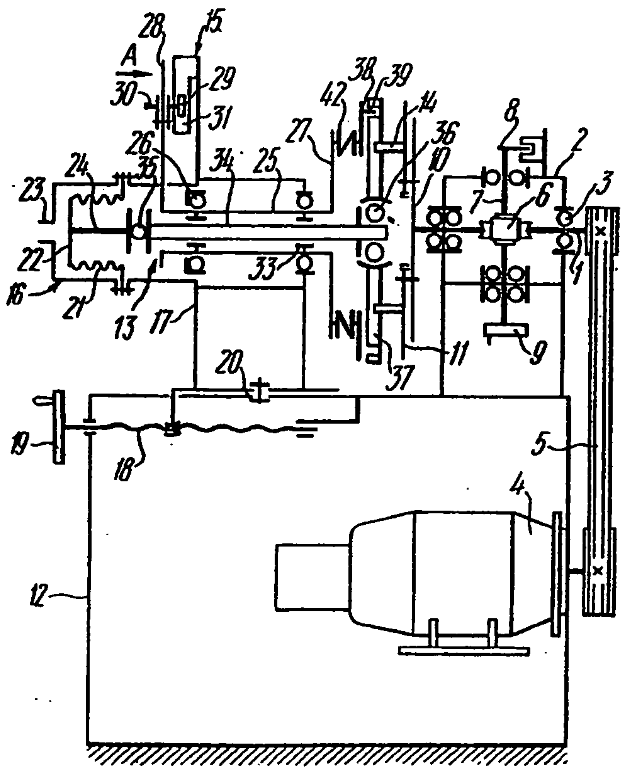
28
15
A
29
30
31
26
35
34
25
27
42
38
39
14
36
10
8
2
3
23
24
7
6
1
22
16
21
13
17
33
37
11
9
20
19
18
5
4
12

FIG.1

1523380 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

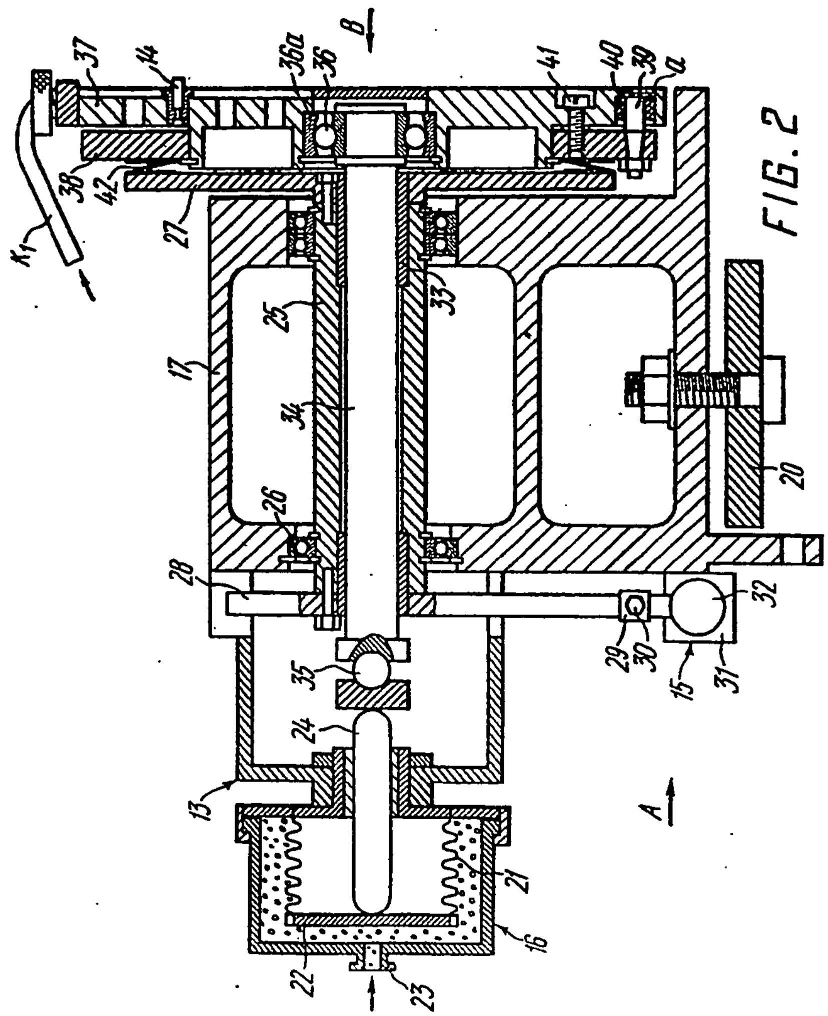

FIG. 2

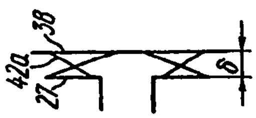

FIG. 5

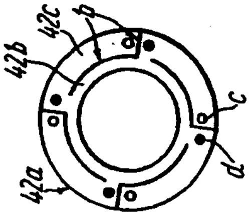

FIG. 4

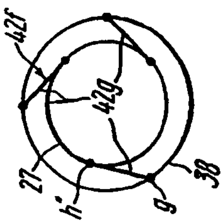

FIG. 7

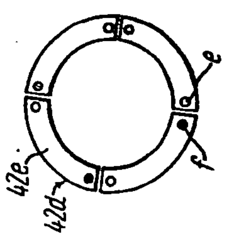

FIG. 6

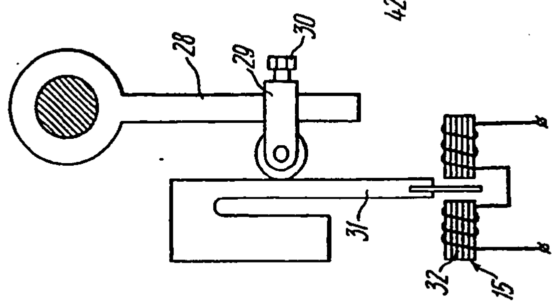

FIG. 3

1523380 COMPLETE SPECIFICATION

5 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 4

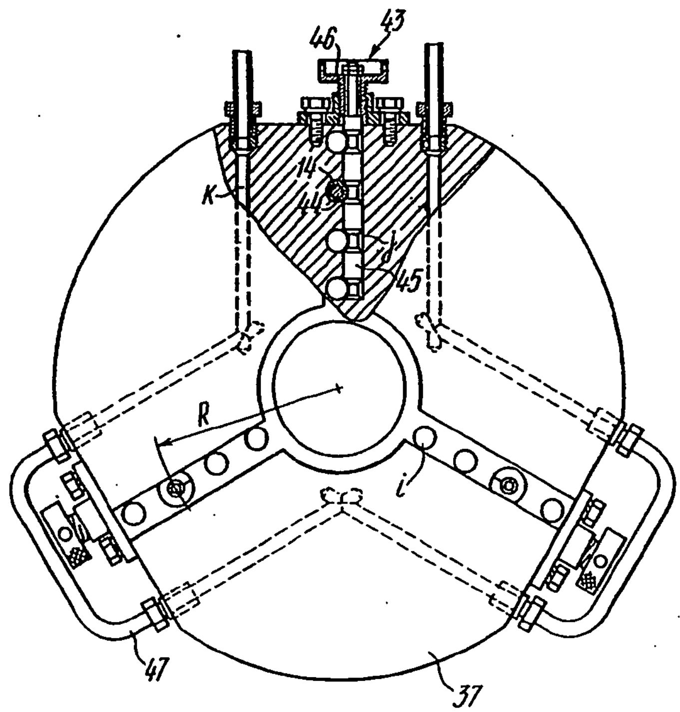

FIG. 8

1523380 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 5

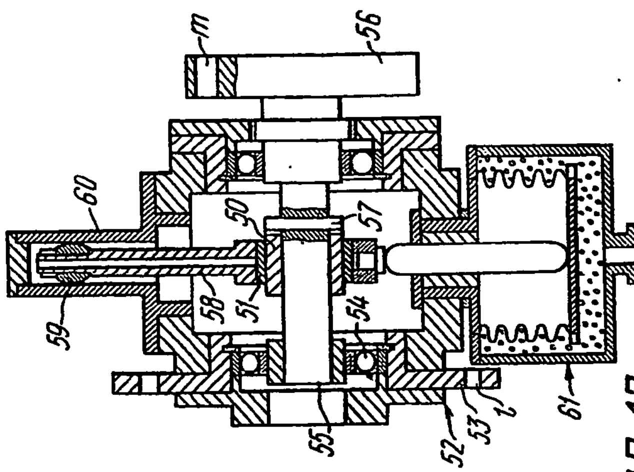

FIG. 13

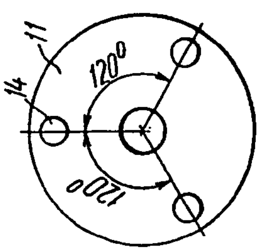

FIG. 10

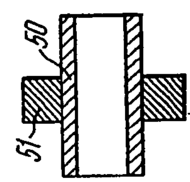

FIG. 12

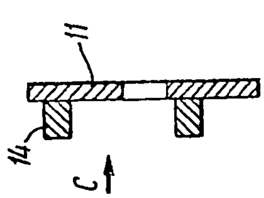

FIG. 9

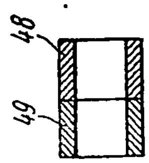

FIG. 11